Space Weather Technical Forecast

Issued on Tuesday, 12 September 2023 at 13:23 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Further M-flares likely (R1-R2 radio blackouts). Chance of G1 Minor storms Day 1 (12 Sep).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate activity, with three M-class flares observed in the last 24 hours. The strongest of these was an M2.5 flare from AR3423 in the west at 12/0707 UTC. There are nine sunspot regions on the visible disc. AR3423 has remained the largest sunspot region, but has remained fairly stable and remains magnetically simple, yet was responsible for the largest flare observed as mentioned. AR3425 has maintained a small and weak delta spot on its trailing portion. AR3429 has seen recent growth stall, while AR3431 has also slowed in development, but does maintain its north-south magnetic configuration. The remaining regions are simple and inactive currently.

A filament eruption and associated coronal dimming was observed around 11/1400 UTC on the southwest disc. The subsequent CME was faint, heading south, and partially obscured by an earlier halo CME that was assessed as far-sided. Analysis has shown that this may give Earth a glancing blow on Day 4 (15 Sep). Another eruption was observed on the northeast limb at 12/0948 UTC, and is awaiting imagery to see if any CME occurred, but given its location it is unlikely to be Earth-directed, pending analysis.

Solar Wind / Geomagnetic Activity: Solar wind was observed at L1 by ACE/DSCOVR, with winds slightly elevated at first around 400 km/s, but have since dropped to slow levels in the past 12 hours, currently sitting around 350-370 km/s. A recent increase has seen solar winds rise to round 410 km/s. The density persisted below background for much of the period, with an increase to average levels was observed from 11/2200 UTC, rising to 10ppcc, with a further increase see recently rising close to 40ppcc. The Interplanetary Magnetic Field (IMF), Bt, was mainly weak and below 9nT, but has recently risen to moderate to strong levels around 18 nT. The north-south component, Bz, was weak and variable between +/- 6nT, but has recently become negative (southward) with a peak of -10nT. Phi angle was negative throughout, but is showing a trend towards becoming positive. Geomagnetic activity was Quiet (Kp 1-2).

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux has been at background. GOES16 high energy (greater than 2MeV) electron flux was at background. The associated 24-hour fluence was well below the Active threshold, with 2.74e6 integrated pfu observed at 12/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be Moderate to Low, with further isolated M-flares likely.

Solar Wind / Geomagnetic Activity: There is one Earth-directed CME in the forecast. This is

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from the filament eruption that occurred around 11/1400 UTC that gave a CME off towards the south. This has been analysed and may give Earth a weak glancing blow on Day 4 (15 Sep). A second eruption from the northeast limb is unlikely to have any Earth-directed component, pending analysis.

The coronal hole and subsequent solar wind and geomagnetic activity forecast is low confidence. This is due to a lack of enhancement from CH44/+ from a similar position on the previous rotation. However this feature is in a good location for a high speed stream (HSS) to arrive at Earth Day 1 (12 Sep), with solar winds around 500-600km/s. Recent observations from DSCOVR and STEREO-A suggest that Earth may be coming into this influence. Enlil is also reducing confidence with a much stronger and earlier arriving coronal hole, but from a more southerly located feature likely CH46/-. Persistence would suggest any enhancement from this feature is most likely late Day 2 or Day 3 (13-14 Sep). Further enhancement is then possible likely from CH47/- later Day 3 or more likely Day 4 (14-15 Sep).

Consequently, geomagnetic activity is forecast to become Unsettled to Active with a chance of G1 Minor Storms Day 1 (12 Sep), easing to Quiet to Unsettled Day 2 (13 Sep), before increasing again into Day 4 (15 Sep), with further Active intervals.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux is expected to remain at background levels, with a very slight chance of an enhancement should any larger flares occur. High energy (greater than 2 MeV) electron flux is expected to be at background Day 1 (12 Sep), then likely responding to the fast wind arrival, and increasing to Moderate to High later day 2 (13 Sep). Confidence is then Low, however any subsequent solar wind enhancement has the potential to drop out flux Day 3 (14 Sep). Overall, the fluence is expected to remain below the Active threshold, but with a slight chance of rising above.

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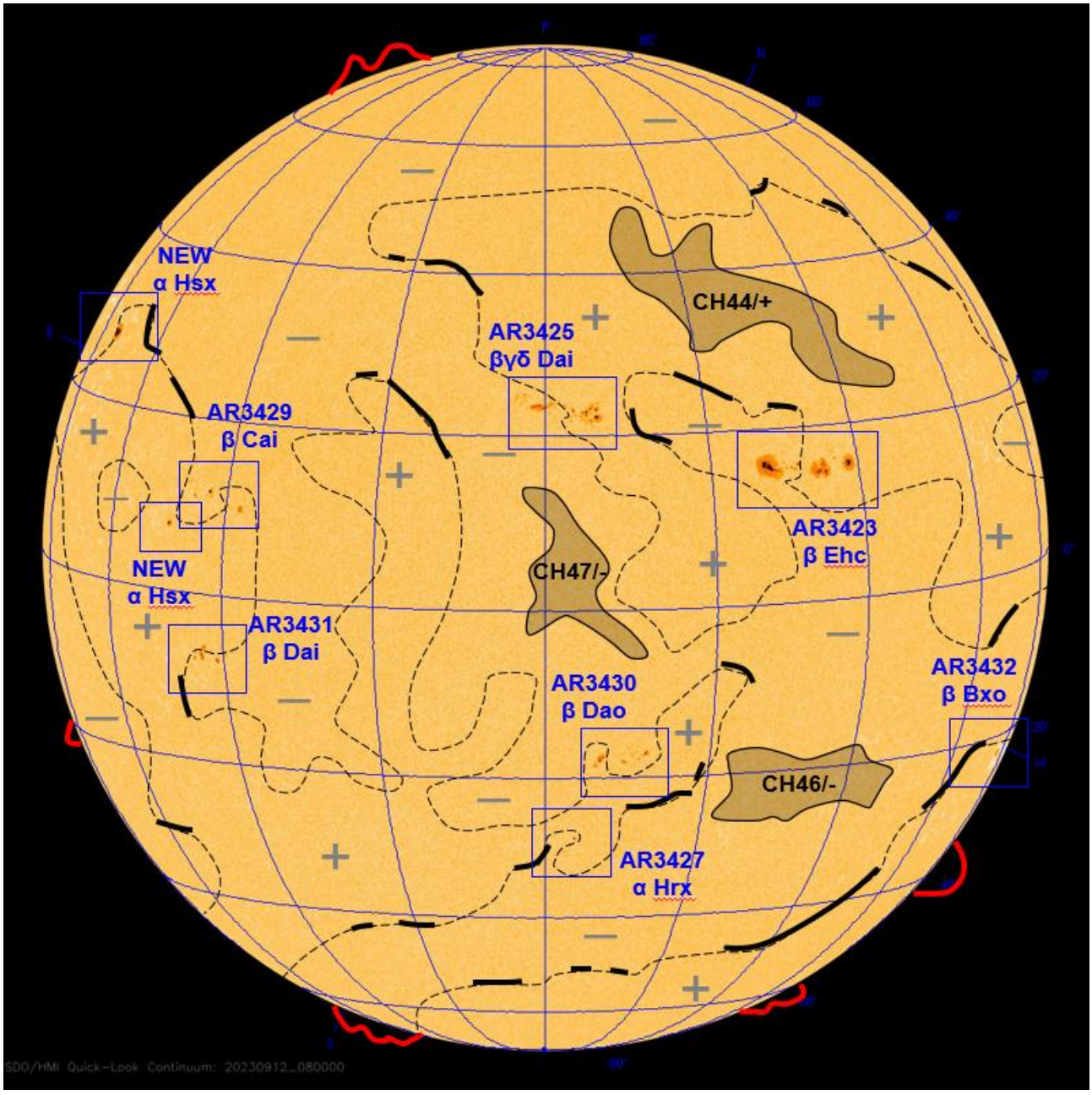
Figure 1. Solar Analysis Valid 12/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There is one Earth-directed CME in the forecast, due to a filament eruption in the south-centre disc around 11/1400 UTC. This gave a CME off the southwest disc, which appeared slow and relatively faint in imagery. Analysis has shown that this may give a glancing impact on Day 4 (15 Sep), with little impact expected. Another eruption was observed on the northeast limb at 12/0948 UTC, and is awaiting imagery to see if any CME occurred, but given its location appears to be around the limb it is unlikely to be Earth-directed, pending analysis.

CH44/+ appears to be the most likely source of any significant enhancement. Based upon the location of the feature, onset of the fast winds from this feature are expected through Day 1 (12 Sep) and given its positive polarity some level of geomagnetic disturbance is likely at this time of year. However, this feature was in a similar location on the Sun on the previous 27-day rotation and yet Earth saw no enhancement from its associated HSS. Observations from STEREO-A, and subsequently from DSCOVR, have shown a recent increase in wind speeds, as well as the Bz component of the IMF becoming negative and a trend towards the phi angle doing likewise. This would suggest that we are just starting to come under the influence of CH44/+.

Enlil already has enhanced solar winds from before Day 1 (12 Sep), due to a more southern or centrally located hole, CH46/- in the southern disc. However, Earth is located around 6N of the elliptic plane, and more likely to connect to northern hemisphere features, suggesting a better chance of enhancement from CH44/+. Furthermore, the only enhancement observed on the previous 27-day rotation was on the equivalent of late Day 2 through Day 3 (13-14 Sep). As the associated phi angle remained negative, this was likely due to a later and therefore weaker connection to southern disc CH46/-, with solar winds only reaching 500km/s. CH47/- in the centre disc is also likely to give a weak enhancement later in the period, perhaps late Day 3 or more likely Day 4 (14-15 Sep).

This creates a complex forecast, with a variety of potential coronal hole interactions, and little assistance from either Enlil or persistence for gaining confidence in the likely outcome.

Overall, the arrival of any CIR, likely associated with CH44/+, looks like it may have just begun at time of issue on Day 1 (12 Sep). A spell of Unsettled to Active geomagnetic activity is forecast due to this, with a chance of G1 Minor Storms. Activity then easing back to Quiet to Unsettled Day 2 (13 Sep), before a further enhancement is possible Day 3 or more likely Day 4 (14-15 Sep) with a transition into any fast wind from CH47/-, combined with any weak enhancement from the glancing CME, bringing further Active intervals, and a slight chance of G1/Minor Storms.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	30	5	10	10
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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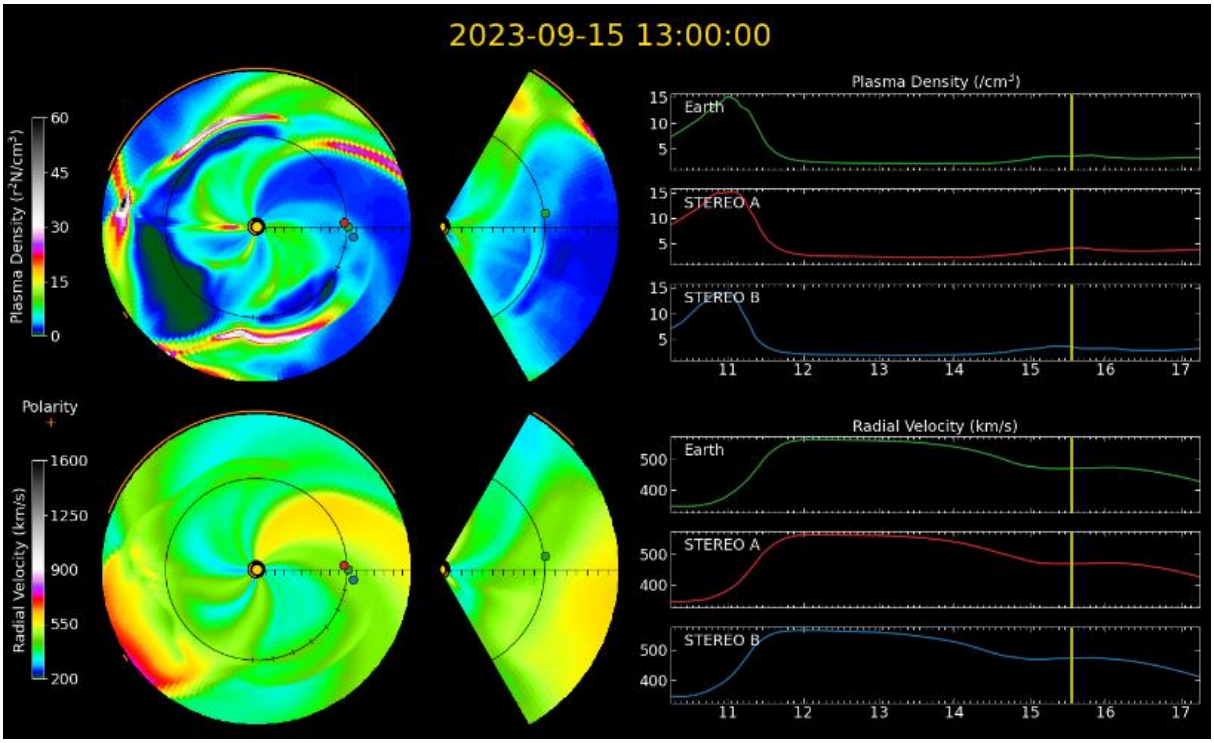
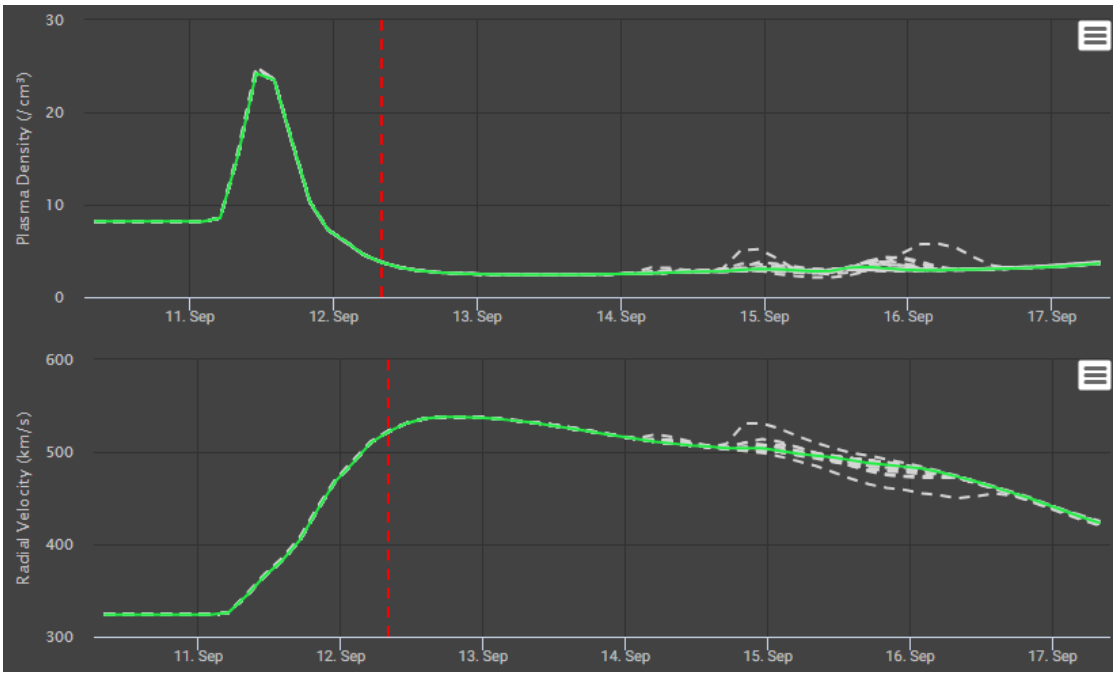
Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
12/0002	Partial	Filament eruption	South-centre disc	450 km/s	15 Sep	Slow, glancing blow at worst.

Figure 2: MOSWOC Enlil run and ensemble, showing possible glancing blow of CME on 15 Sep





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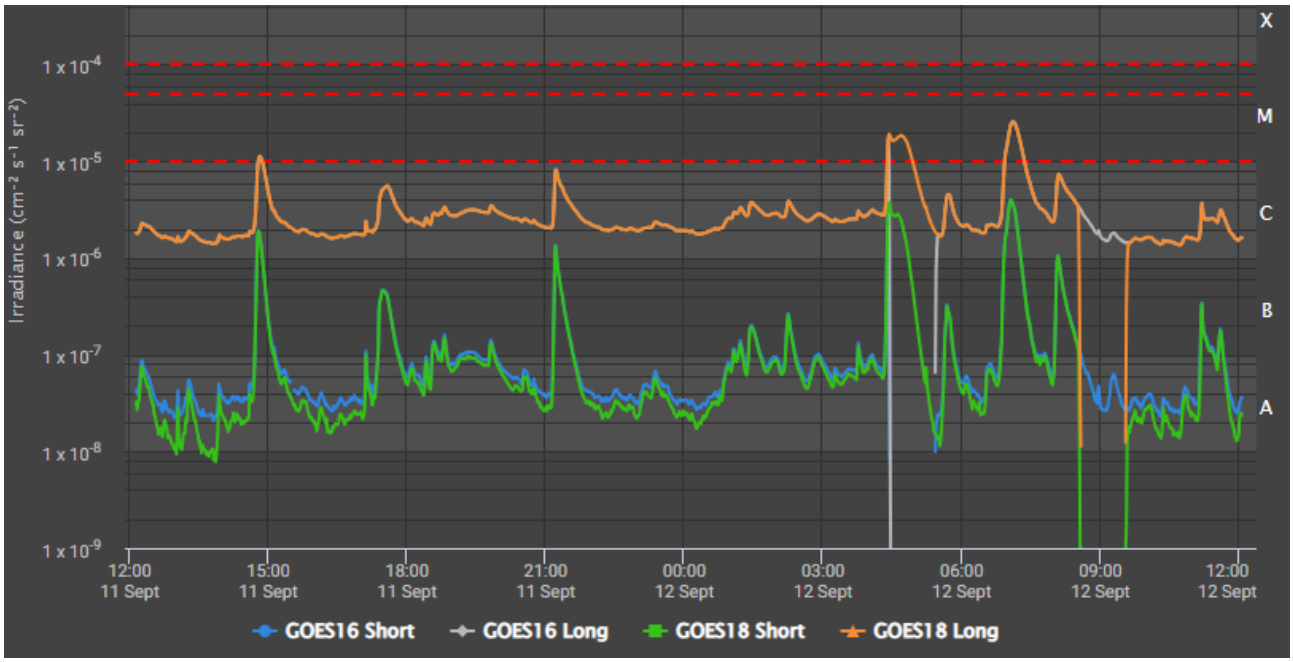
Radio Blackouts - X-Ray Flares:
Moderate to Low activity is expected to continue with an ongoing likelihood of isolated M-class flares.

There are nine active regions visible on the disk, the majority of which have been either stable or decreasing in complexity in the last 24 hours. AR3423 remains the largest sunspot region, and has been responsible for the largest observed flare in the past 24 hrs, however it has remained stable and relatively magnetically simple. AR3425 is now moving into the western hemisphere, and has maintained a small and weak delta spot in its trailer portion. Elsewhere, AR3429 and AR3431 have seen recent growth stall, albeit AR3431 does maintain a north-south magnetic configuration. These 4 regions have seen flare activity in the past 24 hrs. Other regions on the disc are smaller and simpler, and have remained fairly inactive.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	60	60	60	60
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: GOES 16 & 18 X-ray flux



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Solar Radiation Storms - (High Energy Protons):
The high energy (greater than 10MeV) proton flux observed by GOES16 is expected to persist at background levels. There remains a very slight chance of flux levels rising in response to any significant flaring as AR3423 and AR3425 continue to move across the western hemisphere.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	10	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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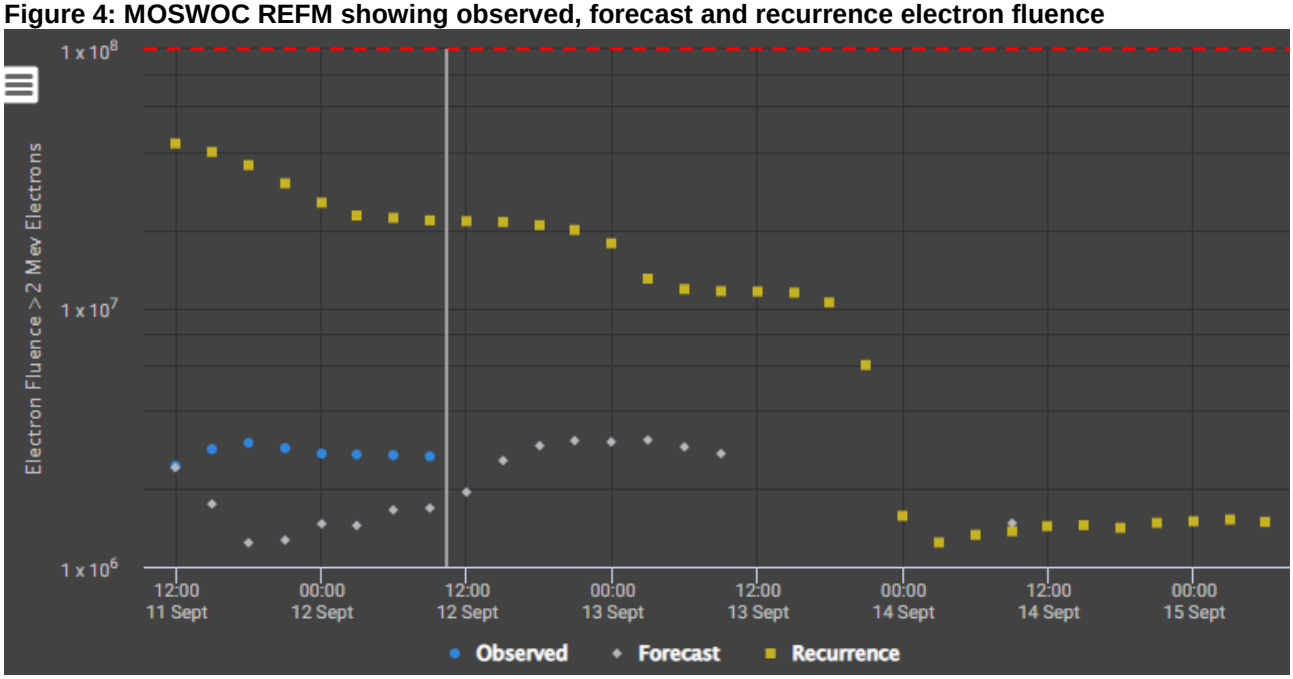
High Energy Electrons Event (≥ 2MeV):
High energy (greater than 2 MeV) electron flux observed by GOES-16 is expected to remain at background Day 1 (12 Sep). Any coronal hole fast wind arrival from CH44/+ has the potential to increase the flux through the Van Allen belts, and observed values at GEO are likely to increase later Day 1 or more likely Day 2 (12-13 Sep), rising to Moderate, perhaps High at diurnal peak. However this rise is low confidence, with the potential for further solar wind enhancement to disrupt the belts and lead to a drop out in observed flux. This is most likely to occur Day 3 (14 Sep).

The associated 24-hour fluence will most likely remain below the Active (1e8 integrated pfu) threshold. Confidence for this decreases Day 2 onward, with a slight chance of rising above, depending on both the strength of the initial enhancement from CH44, but also the length of time until any drop out occurs from any subsequent enhancement. MOSWOC REFM is considered to be giving good guidance until the onset of any fast winds.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	10	20	10
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 4: MOSWOC REFM showing observed, forecast and recurrence electron fluence



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